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ABSTRACT

For a group of 165 fourth- and fifth-grade students, four achievement test scores were correlated with success on nine tests designed to measure three cognitive functions: sustained attention, successive processing, and simultaneous processing. This experiment was designed in accordance with Luria's model of the three functional units of the brain. The nine cognitive test scores were factor analyzed and results supported the hypothesized three factors. The students were divided into high and low groups on each factor and the reading, spelling, mathematics, and reasoning tests were analyzed in a 2x2x2 multivariate and univariate analysis of variance. Results showed all three factors were related to success in spelling and reading. However, mathematics success was most closely related to the simultaneous processing factor and not significantly related to the sustained attention factor. (CTM)

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Cognitive Processes and Achievement[1]

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Luria (1966, 1973) distinguishes three principal functional units of the brain. These are the arousal, processing and programming units. The processing unit is engaged in two types of integrative activity which Luria calls simultaneous and successive processing. Simultaneous processing is the integration of individual stimuli arriving at the brain into simultaneous and primarily quasi-spatial groups, where as successive processing involves the integration of stimuli into temporally organized successive series. The arousal unit is the link by which the mechanism of the orienting reflex is bound with the mechanism of memory; the unit that has an activating or inhibiting function. The programming unit concerns itself with the planning or execution of the other units. The processing unit has been operationalized by Das, Kirby and Jarman (1975) and Randhawa and Hunt (1979) and a dimension of sustained attention has been operationalized in a programme of research by Fitzgerald (Note 2).

Leong (1975), Kirby and Das (1977) and Randhawa and Hunt (1979) have all pointed out the necessity for and integration of the successive and simultaneous processing activities for the successful completion of a particular task, i.e., the working of the two in concert may be the essence of intelligent behaviour. Kirby and Das (1977) demonstrated that those students who are high in simultaneous and successive processing are also high in school achievement, though neither by itself is sufficient for high achievement. School achievement was measured by the Gates-MacGinite reading test and the Lorge-Thorndike. Cummings and Das (1977) obtained only a main effect on the simultaneous processing factor for decoding and comprehension performance in reading. No study has attempted to relate the arousal and processing units to achievement although Hunt (1979) has shown that there is a significant difference between intentional and incidental learning outcomes on a measure of sustained attention.

In the present study an attempt has been made to examine the effects of

the processing and arousal units on selected achievement variables.

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The subjects were 165 students comprising the whole of Grade 4 and 5 in one school in Armidale, NSW. The mean CA was 130 months.

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The following tests were administered to 165 students, as part of a research project conducted by Fitzgerald (Note 2). The tests administered normally compose the simultaneous-successive battery as used in other reported studies, with the addition in this instance of an additional test to measure sustained attention. All tests were administered as group tests by the author.

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The intercorrelations among the nine variables were subjected to an unrestricted common factor analysis using the COSA programme of McDonald and Leong (1976). Confirmatory factor analysis uses existing theory as a reference against which empirical data is tested. Essentially it is based on an unrestricted factor model wehre the number of factors is testable using a maximum likelihood method. Models of 2, 3 and 4 factors were tested. A 3-factor structure was

acceptable [$\chi^2(12) = 10.7$, $p < .05$]. The reader is referred to McDonald (1978) for further details. The resulting factor solution was subjected to a varimax rotation. The factor structure is given in Table 1.

Insert Table 1 about here

The factor scores for each of the 165 students on the three factors were obtained and a median split of these scores on each factor was taken so that each student was categorized on a high-low dichotomy on each factor. The achievement variables were then analyzed in a 2 (high-low simultaneous) x 2 (high-low successive) x 2 (high-low attention) multivariate (MANOVA) and univariate (ANOVA) analysis of variance. Because of the differences in cell sizes, the MANOVA and ANOVA effects were tested conservatively by entering a particular effect last in the analyses.

Results and Discussion

The multivariate main effects for the simultaneous [F (4, 138) = 6.1, $p < .001$] and successive [F (4, 138) = 6.4, $p < .001$] factors were significant with all corresponding univariate main effects significant also indicating that the high simultaneou- and successive groups did better on all the achievement variables than the respective low simultaneous and successive groups.

The multivariate main effects for the attention factor was significant [F (4, 138) = 2.9, $p < .05$]; however, only spelling and reading produced significant univariate differences between the high and low attention groups in favour of the high group.

A significant three-way multivariate interaction was obtained [F (4, 138) = 2.8, $p < .05$]; however, the univariate interaction was significant only for spelling and reading. The cell means and standard deviations are given in Table 2 and Figures 1 and 2 illustrate these interactions.

Insert Table 2 about here

Insert Figures 1 and 2 about here

In order to understand the three-way interaction, analyses of simple effects were carried out at each level of the three factors. Two significant multivariate two-way interactions were obtained. The first of these was between the successive and attention factors for the high simulaneous group [F (4, 67) = 2.83, p < .05] with corresponding significant univariate interaction on the spelling variable [F (1, 70) = 5.67, p < .05]. The second significant multivariate interaction was between the simultaneous and successive factors for the high attention group [F (4, 66) = 3.10, p < .05] with corresponding significant univariate interaction on the reading variable [F (1, 69) = 3.89, p < .06].

From the MANOVA and ANOVA results it would appear that if a student is highly efficient in processing information simultaneously and successively and if this is coupled with a high degree of sustained attention, then the student is efficient in the areas of spelling and reading; however, if there is a deficiency in one of the areas, then a compensatory effect takes place. That is to say that the programming unit may have developed differential ways of dealing with this inefficiency through the more proficient integration of the two efficient areas. However, this is not to say that a particular task does not require also appropriate processing units for its successful completion. Table 3 shows the correlations between the factor scores and the achievement variables.

Insert Table 3 about here

It can be seen from the table that for success in mathematics, proficiency in

simultaneous processing is necessary whereas sustained attention plays a minimal role. On the other hand for spelling and reading, sustained attention plays a major role. Success in reading, as measured by the Gapadol test, is dependent upon the preceding and subsequent text. Similarly, spelling requires paying particular attention to the preceding and subsequent letters. It is not surprising, therefore, that spelling and reading are correlated with the three factors. On the other hand, the mathematics tests may not be so dependent upon such contextual clues, but more dependent upon observing interrelationships among variables.

Not only then is optimal achievement dependent upon the correct choice of the functioning units necessary for a specific tasks, and the integration of these, but also dependent upon the best orchestration, which includes compensatory activities, of the units an individual has available for a particular task. These orchestrational activities that originate in the programming unit may be the key to success in cognitive tasks.

Kirby and Das (1977) suggested that successful training in either form of processing should increase the level of achievement. Krywaniuk and Das (1976) demonstrated this with successive processing. However, devising ways to increase the proficiency of a processing unit may or may not increase the efficiency in achievement, for the deficiency may be the lack of the metacognitive process necessary to utilize proficiently the processes even when they are maximally efficient.

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Footnotes

[1]Paper presented at the American Educational Research Association Conference. Boston, April 1980.

Table 1

Varimax Factor Loadings for

the Battery of Tests (N=165)

Variable	Successive	Simultaneous	Attention	h^2
Matrix A	16[a]	84	07	73
Matrix B	05	66	03	44
Figure Copying	30	59	09	45
Hidden Figures	20	53	24	38
Digit Span	78	19	24	71
Letter Span	75	15	23	64
Word String	60	30	28	53
Digit Attention	21	14	75	63
Letter Attention	35	08	74	68
% Variance	20.7	21.6	15.3	57.6

[a]Rounded to two places and decimals omitted.

Table 2

Means and Standard Deviations for
Eight Groups on Achievement Variables

Group	Size	Variables							
		Reading		Spelling		Math 1		Math 2	
		M	SD	M	SD	M	SD	M	SD
Hi Attn - Hi Succ - Hi Sim	14	33.0	7.4	58.7	13.7	27.4	7.7	19.2	7.2
Hi Attn - Hi Succ - Lo Sim	20	32.1	3.4	54.3	13.5	21.3	5.5	15.6	5.0
Hi Attn - Lo Succ - Hi Sim	21	31.9	4.2	52.5	16.6	20.9	5.3	16.7	5.7
Hi Attn - Lo Succ - Lo Sim	18	25.5	7.8	38.0	18.0	19.6	3.4	14.2	4.2
Lo Attn - Hi Succ - Hi Sim	22	32.7	6.8	59.2	16.5	27.0	8.6	21.5	8.6
Lo Attn - Hi Succ - Lo Sim	21	25.7	7.0	40.8	18.6	20.0	5.6	14.6	3.9
Lo Attn - Lo Succ - Hi Sim	17	26.8	8.8	34.4	18.2	21.2	4.3	15.9	3.9
Lo Attn - Lo Succ - Lo Sim	16	25.8	8.5	35.7	19.5	18.5	3.7	13.6	3.6

Table 3

Correlations Between Factor Scores and Four Achievement Variables

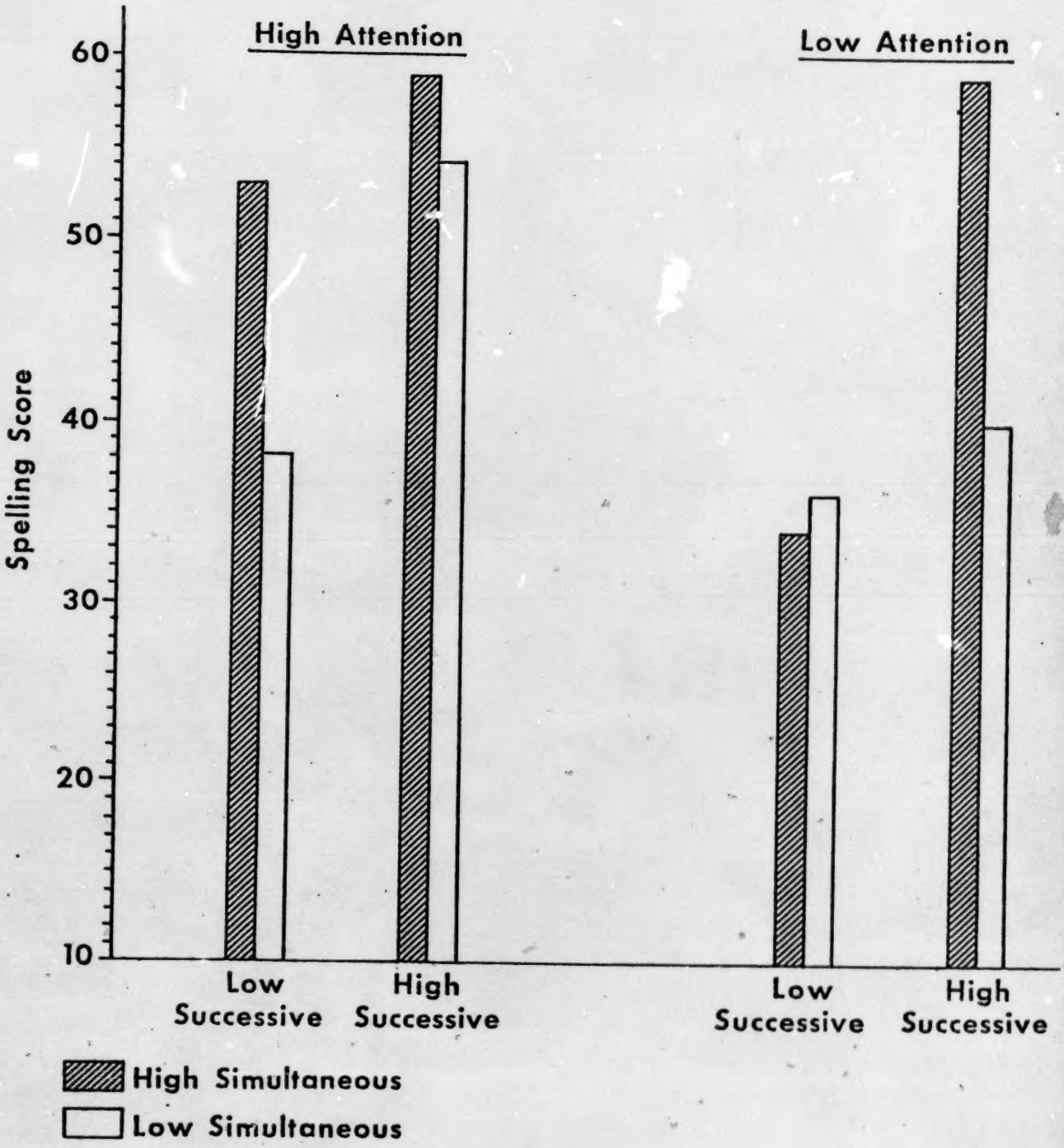
	Varimax Factor		
	Successive	Simultaneous	Attention
Spelling	.39*	.27*	.35*
Math 1	.31*	.40*	.10
Math 2	.22*	.36*	.07
Reading	.27*	.30*	.40*

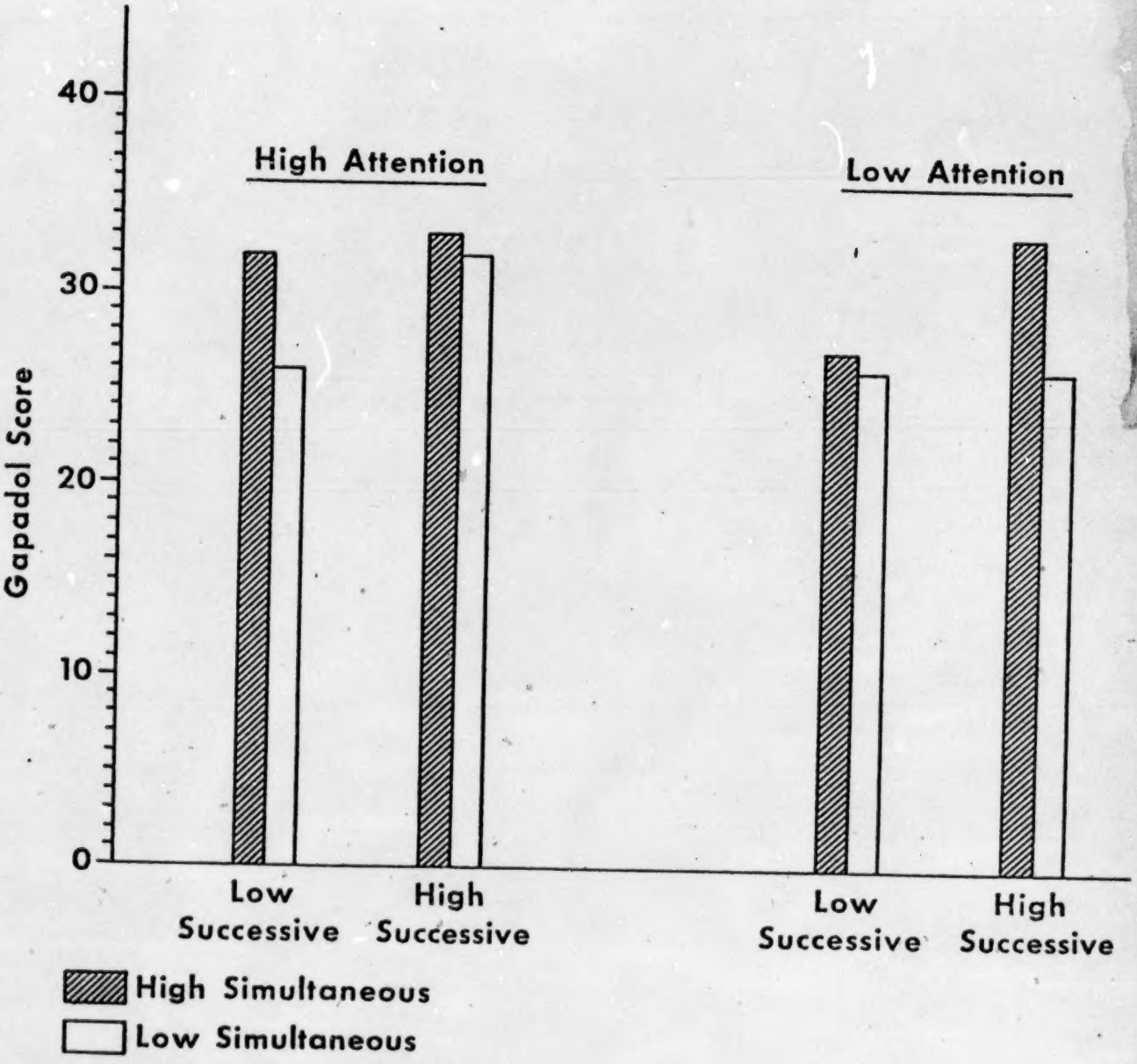
* $p<.05$

Figure Caption

Figure 1. Three-way interaction for the spelling variable.

Figure 2. Three-way interaction for the reading variable.


High Attention
Low Attention
Spelling Score
60
50
40
30
20
10
Low Successive
High Successive
Low Successive
High Successive
High Simultaneous
Low Simultaneous


40
30
20
10
0
Gapadol Score
High Attention
Low Attention
Low Successive
High Successive
Low Successive
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High Simultaneous
Low Simultaneous

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It can be seen from the table that for success in mathematics, proficiency in

simultaneous processing is necessary whereas sustained attention plays a minimal role. On the other hand for spelling and reading, sustained attention plays a major role. Success in reading, as measured by the Gapadol test, is dependent upon the preceding and subsequent text. Similarly, spelling requires paying particular attention to the preceding and subsequent letters. It is not surprising, therefore, that spelling and reading are correlated with the three factors. On the other hand, the mathematics tests may not be so dependent upon such contextual clues, but more dependent upon observing interrelationships among variables.

Not only then is optimal achievement dependent upon the correct choice of the functioning units necessary for a specific tasks, and the integration of these, but also dependent upon the best orchestration, which includes compensatory activities, of the units an individual has available for a particular task. These orchestrational activities that originate in the programming unit may be the key to success in cognitive tasks.

Kirby and Das (1977) suggested that successful training in either form of processing should increase the level of achievement. Krywaniuk and Das (1976) demonstrated this with successive processing. However, devising ways to increase the proficiency of a processing unit may or may not increase the efficiency in achievement, for the deficiency may be the lack of the metacognitive process necessary to utilize proficiently the processes even when they are maximally efficient.

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Footnotes

[1]Paper presented at the American Educational Research Association Conference. Boston, April 1980.

Table 1

Varimax Factor Loadings for

the Battery of Tests (N=165)

Variable	Successive	Simultaneous	Attention	h^2
Matrix A	16[a]	84	07	73
Matrix B	05	66	03	44
Figure Copying	30	59	09	45
Hidden Figures	20	53	24	38
Digit Span	78	19	24	71
Letter Span	75	15	23	64
Word String	60	30	28	53
Digit Attention	21	14	75	63
Letter Attention	35	08	74	68
% Variance	20.7	21.6	15.3	57.6

[a]Rounded to two places and decimals omitted.

Table 2

Means and Standard Deviations for
Eight Groups on Achievement Variables

Group	Size	Variables							
		Reading		Spelling		Math 1		Math 2	
		M	SD	M	SD	M	SD	M	SD
Hi Attn - Hi Succ - Hi Sim	14	33.0	7.4	58.7	13.7	27.4	7.7	19.2	7.2
Hi Attn - Hi Succ - Lo Sim	20	32.1	3.4	54.3	13.5	21.3	5.5	15.6	5.0
Hi Attn - Lo Succ - Hi Sim	21	31.9	4.2	52.5	16.6	20.9	5.3	16.7	5.7
Hi Attn - Lo Succ - Lo Sim	18	25.5	7.8	38.0	18.0	19.6	3.4	14.2	4.2
Lo Attn - Hi Succ - Hi Sim	22	32.7	6.8	59.2	16.5	27.0	8.6	21.5	8.6
Lo Attn - Hi Succ - Lo Sim	21	25.7	7.0	40.8	18.6	20.0	5.6	14.6	3.9
Lo Attn - Lo Succ - Hi Sim	17	26.8	8.8	34.4	18.2	21.2	4.3	15.9	3.9
Lo Attn - Lo Succ - Lo Sim	16	25.8	8.5	35.7	19.5	18.5	3.7	13.6	3.6

Table 3

Correlations Between Factor Scores and Four Achievement Variables

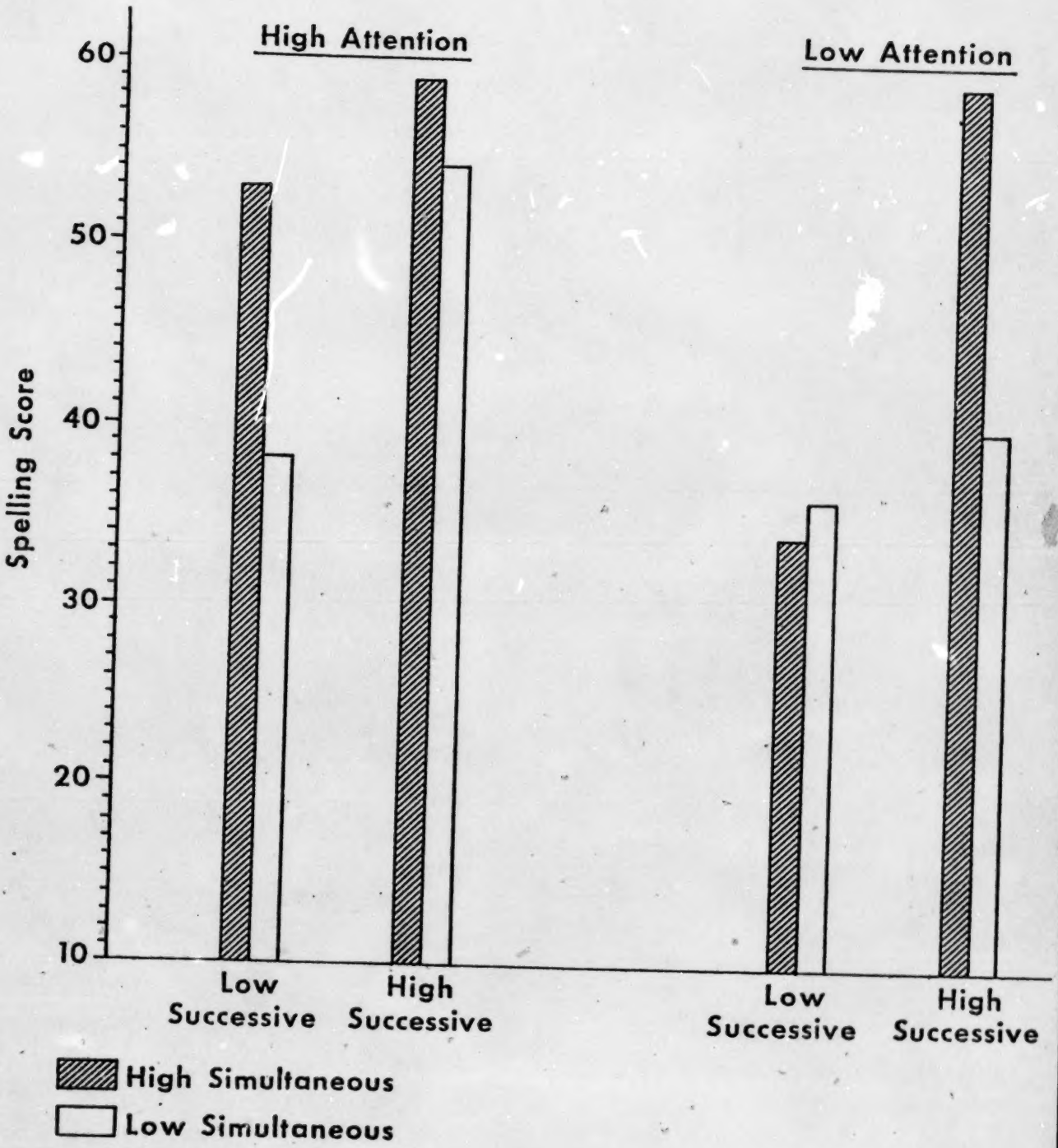
	Varimax Factor		
	Successive	Simultaneous	Attention
Spelling	.39*	.27*	.35*
Math 1	.31*	.40*	.10
Math 2	.22*	.36*	.07
Reading	.27*	.30*	.40*

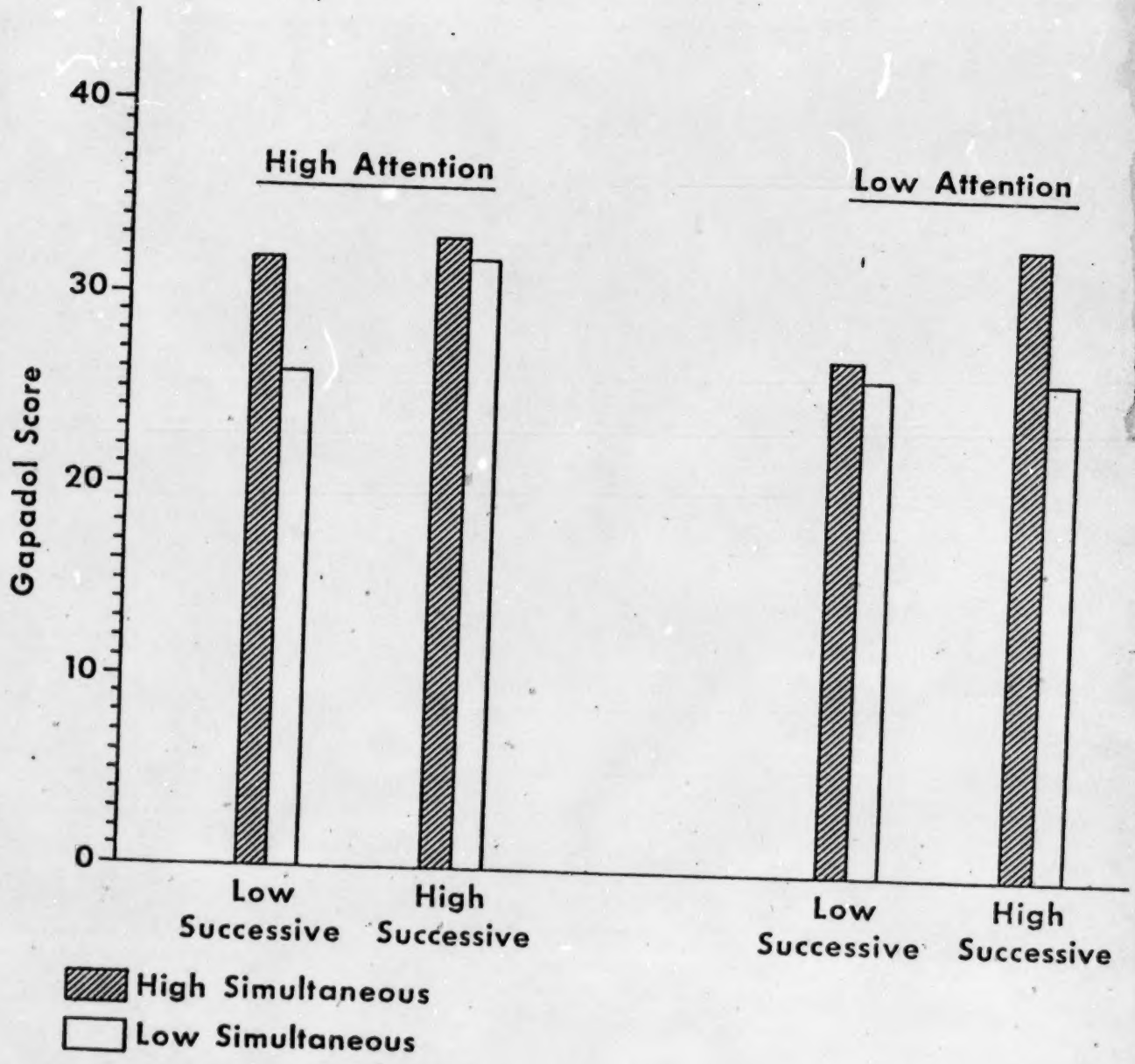
* $p<.05$

Figure Caption

Figure 1. Three-way interaction for the spelling variable.

Figure 2. Three-way interaction for the reading variable.


High Attention
Low Attention
60
50
40
30
20
10
Spelling Score
Low Successive
High Successive
Low Successive
High Successive
High Simultaneous
Low Simultaneous


40
30
20
10
0
Gapadol Score
High Attention
Low Attention
Low Successive
High Successive
Low Successive
High Successive
High Simultaneous
Low Simultaneous